GINNING AND SPINNING PERFORMANCE OF STANDARD AND PUBESCENT STRAINS OF AMERICAN PIMA COTTON

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GINNING AND SPINNING PERFORMANCE OF STANDARD AND PUBESCENT STRAINS OF AMERICAN PIMA COTTON

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INTRODUCTION

Development and release of strains and varieties with improved yield characteristics is an objective of the ARS Pima Breeding and Improvement Program. Many of the Pima strains developed under the higher yield objective were very pubescent on all plant parts. Strain selection for high yield from a group of materials also seemed to be an unconscious selection for high pubescence. Some of these high-yielding strains also matured early. Preliminary yield testing of the high pubescence strains showed 10 to 50 percent yield advantage over check varieties, with a 5-year average yield advantage of 31 percent. A yield increase of this magnitude is an effective means of increasing the producer's per acre profit.

The highly pubescent strains were expected to be more difficult to clean in the gin than the standard varieties. If so, the grades and resulting price per pound would be lower, partially countering the increased producer return from higher yields.

Pima cotton is used in specialty markets requiring high-quality fiber. The commercial release of a new variety that does not meet the quality requirements of these specialty markets, even though it offers promise of higher yields and higher producer profit, appears unwise.

Because of these concerns, a ginning and spinning study was conducted to determine the spinning performance and end-use value of a highly pubescent strain and a standard variety of Pima cotton. A seed cotton cleaning variable was included in the ginning treatments to determine if more extensive cleaning in the gin would improve the mill processing performance of the pubescent strain.

Varietal Characteristics

An early maturing, highly pubescent strain that survived several stages of performance testing was E-1097 63-1216. This strain was later identified as E-2 for regional testing. In preliminary testing of E-2 and Pima S-3 (a low pubescent cultivar recommended for high elevation), E-2 averaged 31 percent higher in yield than Pima S-3. Fiber length and 22's yarn strength were the same for both cottons. E-2 had a higher micronaire and whiter fiber than Pima S-3. Pima S-4 has become the principal cultivar for high elevations and was used as the standard check variety in the ginning and spinning studies. Regional variety test comparisons of E-2, Pima S-3, and Pima S-4 are summarized in table 1. The data are averages for high, intermediate, and low elevation production regions in Texas, New Mexico, and Arizona. Elevation had little effect on cultivar performance except for yield response. E-2 produced 23 and 1 percent more lint than Pima S-4 at high and intermediate elevations, respectively, but produced 23 percent less lint at low elevations. E-2 had a smaller boll with fewer seed per boll than Pima S-4. Pima S-4 had shorter average plant height than E-2 and Pima S-3.

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TABLE 1.—*Pima regional test summary for 3 cultivars, 1971-72*

Plant, fiber, and processing measurement	Cultivar		
	E-2	Pima S-3	Pima S-4
Lint yield kg/ha:			
For elevations above 762 m	953	748	772
For elevations between 457 and 762 m	552	527	544
For elevations below 457 m	583	460	800
Lint pct	34.9	34.5	36.4
Boll size g	2.96	3.39	3.50
Seed index	12.2	12.2	12.2
Lint index	6.5	6.5	7.0
Seed per boll No.	15.8	18.0	18.3
Plant height m	1.155	1.152	0.878
2.5-percent span length in	1.39	1.43	1.41
Uniformity ratio pct	51	49	50
Micronaire reading	4.20	3.58	3.75
Fiber strength g/tex	28.6	28.1	28.7
Yarn skein strength:			
22's	168	167	170
50's	63	67	67
80's	34	36	36
Manufacturing waste pct	34.4	30.1	26.5
Colorimeter:			
Reflectance Rd	72	67	70
Yellowness +b	8.8	10.6	9.9

Production and Harvesting Conditions

The cotton for these tests—pubescent strain E-2 and commercial variety Pima S-4—was produced on the Texas A&M University Agricultural Research Station at El Paso. The seed were planted on April 16, 1971, in alternating field plots. Seasonal cultural practices were normal for irrigated cotton production in the lower El Paso Valley. Chemical applications included an insecticide for beet armyworm control early in the season and a lay-by herbicide application. The last irrigation was August 20—earlier than normal, not anticipating the hot weather that occurred in September. A light frost occurred on October 20 and desiccated the tops of the plants. The field reps of both cottons were harvested on October 22, 23, and 24 for ginning reps 3, 2, and 1, respectively. The cotton was spindle-picked, with an average of 73 percent of the total crop picked in this first harvest. The seed cotton was transported to the Southwestern Cotton Ginning Research Laboratory, Mesilla Park, N. Mex., where ginning tests were conducted October 28 and 29.

Seed Cotton Condition

The composition of the cottons on the wagon, based on seed cotton fractionation samples, is shown in table 2. Original total trash composition between the two cottons did not differ. A difference between the cottons was noted in the fine trash and mote fractions, Pima S-4 having higher

TABLE 2.—*Wagon seed cotton trash and moisture content*

	E-2	Pima S-4	
	TRASH CONTENT		
Material:		*Percent*	
Burs	2.5	2.8	NS
Sticks	.3	.4	NS
Fine trash	3.8	4.6	.05
Motes	2.2	1.1	.01
Total trash	8.8	8.9	NS
	MOISTURE CONTENT		
	8.6	8.5	NS

fine trash content and E-2 having higher mote content. These cottons did not differ when mote and fine trash fractions were combined, however. These two items do not exactly separate on the different screens of the fractionator—considerable fine trash is in the mote fraction. The quantities of trash contained in the two cottons probably did not differ overall.

Moisture content of the two cottons on the wagon was not significantly different, averaging 8.5 percent.

GINNING PERFORMANCE

The three field replications of the two cottons, E-2 and Pima S-4, were subjected to two ginning treatments, a moderate or typical seed cotton cleaning system for roller ginning and a more elaborate seed cotton cleaning system. The ginning system description, sampling procedures, and statistical procedures are outlined in the appendix.

Seed Cotton Cleaning

The response of the cottons to the different seed cotton cleaning systems is shown in table 3. The elaborate cleaning system removed more trash per unit of seed cotton input and had a higher seed cotton cleaning system efficiency than the moderate treatment. The two cottons expressed the expected response: E-2 gave up less trash per unit of seed cotton input and had a lower seed cotton cleaning system efficiency than Pima S-4. However, the separate treatment means for trash removed per unit of seed cotton input and seed cotton cleaning system efficiency show that the moderate seed cotton cleaning system removes almost as much trash from Pima S-4 as is removed from E-2 with the elaborate cleaning system.

The pubescent character of E-2 was expected to make fine trash removal difficult. The percentage of combined fine trash and motes removed during seed cotton cleaning is shown in table 4. These data express the same trend as that previously discussed for percentage of total trash removed in seed cotton cleaning. This is reasonable considering that motes and fine trash represented 66.2 percent of the total trash for these cottons. Of the total trash, burs were 29.3 percent and sticks 4.5 percent.

Lint Cleaning

Lint cleaning system performance data also are shown in table 3. The lint cleaning system removed less trash following the elaborate seed cotton cleaning system than it removed following the moderate seed cotton cleaning system. Less trash was in the lint following elaborate seed cotton cleaning, and that which remained was more difficult to remove. However, the percentage of trash removed by the lint cleaning system for the two cottons did not differ.

TABLE 3.—*Seed cotton cleaning system and lint cleaning system performance*

Treatment: Gin cleaning	Treatment: cultivar	Trash removed from seed cotton per 100 lb seed cotton input	Seed cotton cleaning system efficiency percentage total trash removed	Trash removed from lint per 100 lb ginned lint	Lint cleaning system efficiency percentage trash removed
		Pounds	*Percent*	*Pounds*	*Percent*
Moderate	Pima S-4	6.1 bc[1]	59.3 c	2.9 c	65.0a
Moderate	E-2	5.3 c	44.8 d	6.4a	59.9a
Elaborate	Pima S-4	9.8a	75.4a	2.3 c	55.9a
Elaborate	E-2	7.3 b	64.9 b	4.4 b	59.0a

[1] Means followed by the same letter or groups of letters are not different based on the 0.05 level of Duncan's Multiple Range Test.

TABLE 4.—*Percentages of fine trash and total trash removed in seed cotton cleaning*

Treatment: Gin cleaning	Treatment: cultivar	Fine trash and motes	Total trash
		Percent	
Moderate	Pima S-4	73.4a[1]	59.3 c
Moderate	E-2	44.9 b	44.8 d
Elaborate	Pima S-4	85.0a	75.4a
Elaborate	E-2	66.5a	64.9 b

[1] Means followed by the same letter or group of letters are not different based on the 0.05 level of Duncan's Multiple Range Test.

No meaningful differences were observed between the two cottons for ginning rate. Cotton from the elaborate seed cotton cleaning system ginned 0.6 pound/inch of roller width per hour slower than the cottons from the moderate seed cotton cleaning system, at levels of 12.3 and 12.9 pounds/inch of roller width per hour, respectively. Lint turnout percentages attributable to the different cottons or seed cotton cleaning systems did not differ. Average lint turnout was 32.2 percent.

FIBER QUALITY

Official Classification

Grade

Cotton grade, derived from comparison with official USDA grade standards, was about two grades higher for Pima S-4 than for E-2. The overall average for Pima S-4 was 3.3, compared with 5.2 for E-2. The two seed cotton cleaning treatments in ginning had little effect on grade levels, as shown in table 5.

Staple

Staple length, as determined by official USDA classification, was not affected by ginning condition and was equivalent for the two strains.

Fineness

E-2 has a significantly coarser fiber than Pima S-4 with approximately equivalent length. This generally results in higher yield but also reduces spinning potential.

Other Fiber Properties

In addition to those factors considered by official classification, other properties of cotton are important and normally contribute significantly to the determination of the end-use value of cotton.

2.5-Percent Span Length

This measurement, obtained from the Digital Fibrograph, is closely related to staple length; however, in some cases, the Digital Fibrograph may be more sensitive to length differences than the cotton classer and, therefore, more highly related to spinning quality. The 2.5-percent span length did not significantly differ for all the treatments studied.

Length Uniformity

This measurement is also obtained from the Digital Fibrograph and is the 50-percent span length divided by the 2.5-percent span length, expressed as a percentage. E-2 has a significantly higher uniformity ratio than Pima S-4, which in itself should result in higher spinning quality for E-2. However, length uniformity in ginned lint is usually positively correlated with micronaire reading so that improved length uniformity may be offset by increases in fiber coarseness.

Color

Measured on the colorimeter, color is an important factor contributing to grade as determined by the classer. In the ginned lint, color grade was significantly lower for E-2; however, color grade of the two strains of cleaned lint did not signifi-

TABLE 5.—*Fiber properties, mill processing, and spinning performance results*

Item	Gin cleaning: Moderate, Pima S-4	Moderate, E-2	Elaborate, Pima S-4	Elaborate, E-2
Raw stock:				
Classer's composite grade index[1]	3.0 b[2]	5.7 a	3.7 b	4.7 a
Classer's staple ... 32d in	45.3 a	46.0 a	46.0 a	46.0 a
Micronaire reading	3.73 b	4.17a	3.77 b	4.20a
Shirley Analyzer ... pct nonlint	2.37 c	5.23a	2.60 c	3.83 b
Colorimeter code:				
Ginned lint	1.33 c	3.33a	1.33 c	2.67 b
Cleaned lint	1.00a	1.00a	1.00a	1.00a
2.5-percent span length ... in	1.37a	1.36a	1.37a	1.37a
Uniformity ratio ... pct	45.7 b	47.0 a	45.0 b	47.3 a
Pressley strength:				
0-inch gage ... 1,000 lb/in²	103.3 a	99.0 b	102.3 a	100.7 ab
⅛-inch gage ... g/tex	33.0 a	33.8 a	32.8 a	32.3 a
Opening and picking:				
Waste ... pct	0.40 c	1.05a	0.43 c	0.72 b
Carding:				
Waste ... pct	2.09a	3.54a	2.18a	2.86a
Neps ... No./100 in² web	2.67 bc	2.00 c	4.33a	3.33ab
Drawing sliver:				
2.5-percent span length ... in	1.43a	1.43a	1.43a	1.43a
Uniformity ratio ... pct	48.7 b	50.0 ab	49.7 ab	50.3 a
Pressley strength:				
0-inch gage ... 1,000 lb/in²	95.3 a	95.3 a	96.0 a	93.7 a
⅛-inch gage ... g/tex	32.5 a	31.9 a	31.6 a	31.8 a
Micronaire reading	3.97 b	4.47a	3.97 b	4.50a
Spinning:				
EDMSH ... No	24.7 b	52.0 a	27.3 b	51.3 a
Lap-ups ... pct	8.9 a	4.1 bc	6.4 b	2.7 c
Break factor ... unit	2535 a	2407 b	2556 a	2428 b
Yarn appearance ... index	110 ab	109 ab	113 a	104 b
Yarn irregularity ... pct	18.5 b	19.4a	18.6 b	19.2a
Yarn neps per 1,000 yd ... No	541 b	1027 a	668 b	1003 a
Single strand strength ... g	123.2 b	118.0 d	126.7 a	121.3 c

[1] American Pima Standards.
[2] Means followed by the same letter or group of letters are not different based on the 0.05 level of Duncan's Multiple Range Test.

cantly differ. This indicated that the trash level of E-2 was sufficiently high to preclude an accurate color measurement in ginned lint.

Trash Content

Nonlint content, as measured on the Shirley Analyzer, was significantly different for the two strains; E-2 had the highest trash level. Furthermore, different ginning conditions produced different trash levels for E-2. The elaborate ginning setup resulted in approximately 1.5 percent less trash in E-2 than the moderate condition.

Fiber Strength

Although Pima S-4 might be a slightly stronger strain, the difference in strength between E-2 and Pima S-4 is of little practical significance.

Fiber Properties After Processing

Fiber tests made from stock taken at different stages of processing often provide interesting in-formation on how different cottons withstand the relatively harsh treatment they receive during opening, cleaning, and carding. Generally, both strains processed reasonably well; fiber properties changed during processing about as would be expected. The difference in micronaire reading became more critical after the combing process in which many of the fine, immature fibers and fine fiber tips were removed by mechanical action, resulting in an overall increase in micronaire reading. On combed sliver, micronaire reading was about 4.0 for Pima S-4 compared with 4.5 for E-2, which is very near the critical limit for spinning into fine yarns.

PROCESSING AND SPINNING PERFORMANCE

Manufacturing Waste

The amount of waste in manufacturing generally is directly related to nonlint content and is important because of its direct economic significance. Some types of waste are the result of management practices in manufacturing—others are directly related to cotton quality. Relative values for the wastes related to cotton quality can be obtained through standard processing procedures in the opening, picking, and carding processes. Pima cotton is used exclusively to produce high-quality combed cotton yarns. The combing process, which mechanically removes the shorter cotton fibers, results in waste known as comber noils. Comber noil removal was held essentially constant by mechanical adjustments in processing and is not subject to comparison as a waste factor; however, opening, picking, and carding waste can be compared. Combined waste for E-2 was significantly higher than for Pima S-4. Ginning condition affected processing waste for the E-2 strain with elaborate ginning, resulting in approximately 1 percent less waste than moderate ginning.

Neps in Card Web

The number of neps observed in the card web was approximately the same for both strains. Ginning condition affected neps equally, with both strains experiencing significantly higher nep counts for the elaborate condition as compared with the moderate condition.

Spinning Performance

Spinning performance, as determined by the number of ends down per thousand spindle hours, was significantly poorer for E-2. Pima S-4 had about half as many ends down as E-2, but there were almost twice as many lap-ups in spinning for Pima S-4. Lap-ups are troublesome and require much more time to repair than a normal broken end. For this reason, the lower lap-up rate for E-2 would partially offset the difference in ends down. Ginning conditions also appear to offset lap-up rates, with the elaborate condition resulting in significantly fewer lap-ups.

Yarn Quality

The overall quality level of yarns produced from the two cottons differed significantly. Pima S-4 yarns were stronger and more even, and had better appearance than E-2 yarns. Ginning conditions affected some of the quality factors, but these effects were overshadowed by differences in the cottons themselves.

SUPPLEMENTARY PROCESSING PERFORMANCE STUDIES

The original ginning and spinning performance studies revealed that high micronaire, rather than high pubescence and associated higher trash levels, could be the critical limiting factor on the acceptability of E-2 for processing into fine yarns. A lower micronaire cultivar from the high-yielding, high-pubescence group was processed at a later date in conjunction with another study. Performance data for this cotton are presented because of their pertinence to the original study objective.

Varietal Characteristics

Another of the early maturing, high-yielding pubescent strains that survived performance testing was E-1125 63-2061-2, later identified as E-4. This strain was a later development than E-2 and was not available for pilot plant scale testing when the original E-2 study was conducted. E-4 is similar to E-2 in yield advantage over current varieties but has lower micronaire than E-2. Micronaire of E-4 is higher than Pima S-3 but is in the same range as Pima S-4. The performance of E-4 in an advanced strain test comparison with E-2, and Pima S-3 is summarized in table 6.

Test Cotton Production, Harvesting, and Ginning

The cottons for these tests, E-4 and Pima S-4, were produced under commercial conditions near Safford, Ariz. The cottons were roller ginned on a commercial gin. Three bales of each cotton were selected for mill processing and spinning performance evaluations. Mill processing procedures were the same as those used for the original study as detailed in the appendix.

TABLE 6.—*Pima advanced test summary for 3 cultivars, Texas (high elevations), 1972*

Plant, fiber, and processing measurement	Cultivar		
	E-4	E-2	Pima S-3
Lint yield ---------kg/ha--	1130	1163	844
Lint----------------pct---	34.9	36.7	35.0
2.5-percent span length in	1.49	1.42	1.46
Uniformity ratio ----pct--	51	53	51
Micronaire reading -------	3.92	4.31	3.56
Fiber strength ----g/tex--	29.1	27.6	26.9
Yarn skein strength:			
22's -----------------	171	161	167
50's -----------------	66	59	68
80's -----------------	36	33	37
Manufacturing waste --pct	35.3	30.8	30.7
Colorimeter:			
Rd-------------------	74	73	68
+b ------------------	9.3	8.9	12.1

Fiber Quality

Ginned Lint

The quality of the two cotton strains was determined by standard industry tests and comparison to official USDA grade standards. The official cotton classer composite grade was three grades higher for Pima S-4 than for E-4 (table 7). Micronaire tests indicated Pima S-4 (3.7) to be slightly finer than E-4 (3.9). They were both officially classed 1⅜-inch staple length cottons. Digital Fibrograph tests showed the Pima S-4 fibers to be of a slightly shorter 2.5 percent span length and of a higher uniformity ratio. E-4 produced highest Pressley strength results but not sufficiently higher than Pima S-4 to be of practical economic importance.

The nonlint content measured on the Shirley Analyzer for E-4 was three times the value recorded for Pima S-4. This higher trash level was also reflected by the Colorimeter codes for the ginned lint. For cleaned lint, no difference between the two varieties was observed.

Results of the test performed on the ginned lint showed Pima S-4 to have the most desirable market properties even though E-4 shows promise of some improvement in fiber properties.

Combed Sliver

The physical properties of the two strains were tested after combing. Changes in physical properties at the combing stage, as compared with ginned lint, were as expected. All the relationships between the two varieties remained unchanged.

Processing and Spinning Performance

Manufacturing Waste

The performance of ginned lint is determined by the fibers' ability to withstand the harsh forces encountered and the amount of waste generated through processing. E-4 produced approximately 3.5 percent more waste than Pima S-4 during the opening, picking, and carding operations. This was to be expected since Shirley Analyzer tests on E-4 had shown an excessive amount of nonlint content. The amount of combing waste was not used in comparison because the percentage removed is held constant by making

TABLE 7.—*Fiber properties, mill processing and spinning performance results*

Item	Pima S-4	E-4
Raw stock:		
Classer's composite grade index [1]	3	6
Classer's staple ... 32d in.	44	44
Micronaire reading	3.7	3.9
Shirley Analyzer ... pct nonlint	3.12 b[2]	9.34a
Colorimeter code:		
Ginned lint	2.0 b	4.8 a
Cleaned lint	1.0	1.0
2.5-percent span length ... in.	1.37 b	1.39a
Uniformity ratio ... pct	45.6	43.8
Pressley strength:		
0-inch gage ... 1,000 lb/in²	102.8 b	107.2 a
⅛-inch gage ... g/tex	33.4 b	35.0 a
Opening and picking:		
Waste ... pct	0.68 b	3.02a
Carding:		
Waste ... pct	2.70 b	4.23a
Neps ... No./100 in² web	5.0	8.3
Drawing sliver:		
2.5-percent span length ... in.	1.42	1.47
Uniformity ratio ... pct	53.0	52.3
Pressley strength:		
0-inch gage ... 1,000 lb/in²	94.3	99.7
⅛-inch gage ... g/tex	32.1	33.1
Micronaire reading	3.8	4.0
Spinning:		
EDMSH ... no.	42 b	69 a
Lap-ups ... pct	6.83a	0.53 b
Break factor ... unit	2534 b	2690 a
Yarn appearance ... index	103	101
Yarn irregularity ... pct	19.5	19.8
Yarn neps per 1,000 yd ... no.	436	770
Single strand strength ... g	130.0	131.3

[1] American Pima Standards.

[2] Means followed by the same letter or group of letters are not different based on the 0.05 level of Duncan's Multiple Range Test.

mechanical changes during the process. The average numbers of neps reported in the card webs were 5.0 for Pima S-4 and 8.3 for E-4. The higher frequency of neps for E-4 probably is associated with the low length uniformity ratio.

Spinning Performance

The criteria used to determine the spinning performance of the two varieties were the number of ends down per thousand spindle hours and the number of ends lapped. E-4 produced approximately 1.5 times the number of ends down as Pima S-4. The number of lap-ups was 6.8 percent for Pima S-4 and 0.5 percent for E-4. Considering the additional time required to repair a lapped end, the spinning performance of the two varieties was roughly equivalent.

Yarn Quality

The factors considered in determining the quality of the yarn manufactured were strength, uniformity, and appearance. Strain E-4 exhibited the highest break factor even though single strand strength did not differ significantly. The irregularity coefficient of variability (CV) was 19.5 percent for Pima S-4 and 19.8 percent for

E-4. The yarn from both varieties received yarn appearance of C+.[2] The overall quality of the yarn manufactured from the two strains was very similar.

[2] Related to yarn appearance index in table 7 as follows:

130 = A	90 = C
120 = B+	80 = D+
110 = B	70 = D
100 = C+	

MARKETING IMPLICATIONS

Marketing implications of the pubescent strains are difficult to assess. Fiber properties appear to be approximately equivalent even though some evidence indicates slight improvements in length and strength in the pubescent strains. Increases in micronaire reading would inhibit their use in fine yarns. The increased trash levels, even with elaborate ginning, would result in lower grades. Unless increased yield can offset the loss in grade, the pubescent strains have little advantage because the current marketing system is not sufficiently sensitive to respond to the small improvement in fiber properties of the pubescent strains.

The spinning performance of the pubescent strains is somewhat puzzling. Ends down levels for E-2 and E-4 are significantly higher than would be expected for Pima cotton with micronaire reading and uniformity ratio of 4.5 and 44, respectively. The level of lap-ups in spinning also is unusual. Normally, precautions must be taken to prevent high levels of lap-ups when spinning Pima cotton, and 5 percent is a typical level. About one-tenth the normal level was observed for the pubescent cottons. This represents a significant quality improvement that should be studied further for possible exploitation. However, it is doubtful that under the present marketing system the pubescent strains could compete successfully with Pima S-4.

SUMMARY AND CONCLUSIONS

A study was conducted to determine if a high-yielding advanced breeding strain of pubescent Pima cotton, E-2, could be adequately cleaned in the gin with typical or elaborate seed cotton cleaning systems and if the cotton gin-processed in this manner would perform in the mill at levels and end-uses currently required of Pima cottons. A currently grown variety, Pima S-4, processed on a typical moderate seed cotton cleaning system, was the standard for comparison.

The total trash content and moisture content of the two cottons were equivalent on the wagon. Therefore, a straightforward interpretation of results was possible. The weight of trash removed from Pima S-4 was higher than the weight from E-2 when averaged for both ginning treatments—bearing out the fact that E-2 is more difficult to clean than Pima S-4. There were no large differences in seed cotton system cleaning efficiency and lint cleaner system cleaning efficiency for E-2 on the elaborate cleaning system and Pima S-4 on the moderate cleaning system. Yet the nonlint content of the ginned lint was higher for E-2 on the elaborate cleaning system than for Pima S-4 on the moderate cleaning system. This same trend was noted for classer's grade. E-2 responded to elaborate seed cotton cleaning more favorably than Pima S-4. These tests indicate (1) that the moderate seed cotton cleaning system is adequate for processing Pima S-4, (2) that an elaborate seed cotton cleaning system would be required to satisfactorily process E-2, and (3) that grades of E-2 processed on an elaborate seed cotton cleaning system could be expected to be lower than grades of Pima S-4 processed on a moderate seed cotton cleaning system.

Comparison of the fiber properties of the two strains indicates that they are approximately equal in quality except for micronaire reading and length uniformity ratio. Theoretically, the higher length uniformity ratio could possibly be reflected in the staple length determination made by the classer; however, the classification system as currently defined does not specifically include a measurement of length uniformity so that any improvement in use value, if it occurred, would likely go unrewarded unless the improvement resulted in higher yields.

The increase in micronaire reading could result in a direct benefit to producers except for the strict limitations on fineness that are peculiar to Pima cotton. The premium range for fiber fineness includes micronaire readings from 3.5 to 4.9. Since Pima is a naturally fine-fibered cotton, significant portions of the crop each year are below the 3.5 level as shown in table 8 for the years 1966 through 1973.

A shift in production to a coarser strain, such as E-2, might be beneficial not only in terms of yield but also in reducing the percentage of the crop that falls below the 3.5 level. The 1969 crop was significantly coarser than usual as shown in table 8. The advantage to the producer is obvious since 85 percent of the crop was in the premium range rather than the nominal 70- to 75-percent range.

The upland cotton producer may safely produce cotton throughout the entire premium range of 3.5 to 4.9 micronaire reading; however, in actuality, the premium range for the Pima producer is from 3.5 to 4.0 because of requirements for fine yarns. The E-2 strain appears to have nothing to offer the Pima industry unless it is grown specifically for a coarse yarn end product. However, this does not appear to be logical from the standpoint of the producer. Increased yield would have to be sufficient to offset significant price differences due to the much lower grade level. Also involved would be an additional severe price decrease, which is related to much lower prices for the coarser yarns that would have to be manufactured from the higher micronaire pubescent cottons. Stated another way, the market could not afford to pay the price for the longer staple cottons if they are to be used in coarse yarns, which can be manufactured from shorter staple cottons. However, these Pima cottons could be used to advantage in blends with shorter staple cottons in coarse, open-end yarns where fiber strength rather than fiber length is a limiting factor.

Supplementary spinning studies, using pubescent strain E-4 and additional Pima S-4 from another location, were performed to verify experimental results observed on differences between E-2 and Pima S-4. Typical commercial ginning procedures for Pima cotton were used for both cottons. Significant differences in spinning quality were observed for the two cottons even though micronaire reading and many other fiber properties were similar. Generally, E-4 performed more poorly than did Pima S-4. Only in lap-ups did E-4 prove superior.

Length uniformity, as measured on the Digital Fibrograph, was considerably lower for these two cottons as compared with the E-2 and Pima S-4 cottons used in the original experiment. Also, uniformity ratio for E-4 was significantly lower than that for Pima S-4 and helps to explain the observed differences in spinning quality. These results, together with the previous results for E-2, indicate that the pubescent strains

TABLE 8.—*Cumulative percentage Pima cotton production for different micronaire readings*

Micronaire reading	Crop year							
	66	67	68	69	70	71	72	73
	Percent							
2.4 and below	--	--	0.1	--	0.1	0.1	--	--
2.5	--	--	.3	--	.4	.2	--	0.1
2.6	0.4	--	.7	0.2	1.2	.6	0.2	.5
2.7	.9	0.2	1.2	.5	2.5	1.3	.7	1.3
2.8	2.2	.6	2.2	1.1	4.5	2.3	1.6	3.0
2.9	4.1	1.3	4.0	1.9	6.5	3.5	3.0	5.1
3.0	7.7	3.5	6.3	3.2	8.9	5.3	5.7	8.4
3.1	11.5	5.7	9.6	5.2	11.7	7.0	9.5	12.5
3.2	17.2	9.2	13.1	7.5	15.6	9.5	15.3	17.6
3.3	23.0	13.1	17.7	10.6	19.4	12.3	21.2	23.1
3.4	31.7	19.7	23.2	14.6	25.0	16.5	29.0	31.1
3.5	38.8	27.8	30.2	21.4	32.5	23.2	39.2	40.0
3.6	50.8	37.4	37.8	29.7	43.2	32.8	51.3	50.7
3.7	59.9	48.8	46.5	39.1	52.3	43.6	62.3	61.6
3.8	72.1	61.3	56.6	51.9	67.7	58.8	73.7	74.2
3.9	80.7	73.2	67.7	62.8	76.2	70.8	82.9	83.3
4.0	89.5	83.5	77.0	74.1	86.5	84.2	90.0	90.8
4.1	94.3	91.2	85.6	84.1	92.0	92.0	94.9	95.5
4.2	97.9	95.9	91.5	90.9	97.3	96.9	98.1	98.1
4.3	99.2	98.4	96.2	95.2	98.8	98.9	99.4	99.2
4.4	99.9	99.5	98.3	97.9	99.5	99.7	99.9	99.8
4.5	100.0	99.8	99.5	99.1	99.8	99.9	100.0	100.0
4.6	---	100.0	99.8	99.6	99.9	100.0	---	---
4.7	---	---	99.9	99.8	100.0	---	---	---
4.8	---	---	100.0	99.9	---	---	---	---
4.9	---	---	---	100.0	---	---	---	---

may be subject to greater influences of environmental factors than Pima S-4 and, consequently, may produce increased variations in fiber properties if adopted for widespread use.

APPENDIX

System Description

Ginning

A moderate or typical seed cotton cleaning system for roller ginning and a more elaborate seed cotton cleaning system were the two ginning treatments. The moderate ginning setup included a drier (220° F inlet), 6-cylinder cleaner, stick machine, 6-cylinder cleaner, feeder, rotary-knife roller gin, and two stages of mill-type lint cleaning. The elaborate ginning set up included a drier (220° F inlet), 6-cylinder cleaner, stick machine, 6-cylinder cleaner, stick machine, stick machine, 6-cylinder cleaner, feeder, rotary-knife roller gin, and two stages of mill-type lint cleaning. Temperature at the drier outlet during processing averaged 145° F. Seed cotton feed rate or cleaning rate was based on a constant automatic feed control setting for all treatments and averaged 5,950 pounds of seed cotton per hour.

Mill processing

Each bale of cotton, representing one experimental condition and weighing approximately 300 pounds, was processed in the Pilot Spinning Laboratory to simulate actual mill conditions. After removal of the bale ties and before processing, samples of cotton were taken throughout each bale for fiber testing. Also, samples were taken at the finisher drawing process to test for possible fiber damage. At the beginning of the combing phase for each experimental condition, the comber was adjusted to remove 14-percent noils (±0.5 percent). The comber drawbox and combing mechanism were adjusted to provide sliver evenness of less than 5-percent irregularity (Uster percent of CV).

Roving was creeled singly into four 252-spindle spinning frames equipped with Duo-Roth drafting systems. New travelers were used for each spinning doff; the frames were run for 30 minutes to break in the travelers and to obtain yarn for sizing. Draft gears were changed, if necessary, to obtain the specified yarn size, and end breakage was recorded at 15-minute intervals during the spinning of a full doff of yarn.

The cardroom and spinning room were kept at 80° F and 50-percent relative humidity throughout the tests.

Opening

Each bale was distributed among three blending feeders equipped with Sargent combs. The cotton was dropped onto a conveyor, which fed into a 15-inch-diameter licker-in beater revolving at 880 revolutions per minute. From the preopening beater, the cotton was carried pneumatically to a Saco-Lowell #12 lattice opener for further opening and cleaning before entering the picker for lap formation.

For processing details, see appendix tables 1, 2, and 3, pages 12 and 13.

Sampling

Ginning

The following samples were taken from each ginning lot: Two seed cotton fractionation samples and one seed cotton moisture sample from the wagon; two seed cotton fractionation samples and one seed cotton moisture sample from the feeder apron; and one large seed sample for foreign matter, moisture, linters, seed damage, and germination determinations. Lint slide samples included one moisture sample and five other samples for classing and the numerous fiber quality determinations. All samples were composited from several locations in the trailer and from three subsampling times at the feeder, seed belt, and lint slide. The following lot weights were recorded: Seed cotton, seed cotton cleaning system trash, lint cleaning system trash, seed (weight estimated from weighing counter), samples, and press lint. Ginning time was recorded and other operational factors were monitored.

Fiber Testing

Fibrograph measurements, Pressley 0-inch gage and 1/8-inch gage strength tests, and micronaire readings were made on four subsamples of ginned lint and one sample of drawing sliver from each bale of cotton. The following measurements were made on each subsample by two technicians:

Instrument	Measurements: Per technician	Measurements: Per sample	Samples	Total measurements per bale or lot
	Number			
Fibrograph	2	4	4	16
Pressley:				
0-inch gage	2	4	4	16
⅛-inch gage	2	4	4	16
Micronaire	1	2	4	8

Color measurements were made on ginned lint samples before and after Shirley Analyzer test.

Official classification data were obtained from the board of supervisory cotton examiners, Memphis, Tenn.

Yarn Testing

From each condition, 10 bobbins of yarn from each of the four spinning frames (40 bobbins) were tested for skein strength and yarn size.

Sixteen bobbins were tested for yarn evenness and imperfections. The sensitivity of the evenness tester was set at 30 percent for thin places and at setting number 4 for thick places and neps. Yarn from each bobbin was tested at 25 yd/min for 5 minutes (2,000 yd/lot). Imperfections are reported per thousand yards.

Single strand strength tests were made on 40 bobbins, 10 breaks per bobbin.

Yarn grade was determined from three yarn boards per condition by three technicians.

Statistical Procedures

Three field replications of the two cottons were subjected to two ginning treatments. The 12-lot ginning study was set up in a factorial treatment arrangement. An effort was made to block the treatments by replication, but because of the problem of moving trailers between lots, the blocking was not complete. Therefore, data were analyzed on the basis of randomized repeated observations without rep blocking. Analyses of variance were based on the following partition of degrees of freedom:

Source	*Degrees of freedom*
Total (corrected)	11
Gins	1
Strains	1
Gins × Strains	1
Error	8

Fiber and yarn manufacturing data were analyzed by Duncan's Multiple Range Test. Error standard deviation was estimated by pooling the standard deviations within treatment conditions. Statistically significant differences in observed means of treatment conditions were determined using the error standard deviation, sample size used to estimate the means, and a probability factor depending on the number of means being compared and the degrees of freedom associated with the error standard deviation.

APPENDIX TABLE 1.—*Processing details: Picking*

Item	Description
Lap width ---- in --	38
Lap weight ---- lb --	40.3
Do ---- oz/yd --	14
Production rate ---- lb/hr --	350
Number and type of beater	1-3 Blade
Do	1 Kirschner
Beater speed:	
3 Blade ---- r/min --	1150
Kirschner ---- r/min --	1050
Beats per inch:	
3 Blade	60
Kirschner	43
Fan speed:	
Back ---- r/min --	1600
Front ---- r/min --	1200
Feed roll diameter:	
Back ---- in --	2.5
Front ---- in --	3.0

APPENDIX TABLE 2.—*Processing details: Carding, drawing, lapping, combing*

Item	Carding	1st Drawing	Lapping	Combing	2d Drawing
Sliver weight delivered ---------- g/yd--	55	45	864	53	55
Production rate per delivery ---------- lb/hr--	15	34	420	35	42
Do ---------- ft/min--	---	265	----	230	265
Do ---------- nips/min--	---	----	----	140	----
Doublings ----------	1	8	20	6	8
Speed:					
Licker-in ---------- r/min--	475	----	----	----	----
Cylinder ---------- r/min--	177	----	----	----	----
Doffer ---------- r/min--	9	----	----	----	----
Crush roll setting ----------	297	----	----	----	----

APPENDIX TABLE 3.—*Processing details: Roving and spinning*

Item	Roving	Spinning
Drafting system ----------	Shaw	Duo-Roth
Weight delivered ---------- hank/lb--	1.75	80
Twist ---------- twist multiplier--	1.10	3.22
Do ---------- turns/in--	1.46	28.8
Spindle speed ---------- r/min--	900	12,000
Front roll speed ---------- r/min--	196	133
Production rate per hour ---------- lb/spindle--	0.6989	0.0022
Ring size ---------- in--	------	2
Package size delivered ---------- in--	10 x 5	-----

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